FURTHER DATA FOR THE CALIBRATION OF THE ANTIQUITY INDICATOR $^{40}Ar/^{36}Ar$ FOR LUNAR SOIL. O. Eugster and E. Polnau, Physikalisches Institut, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland.

Our knowledge on the solar-wind activity during the last several 10^9 years (Ga) has mainly come from the study of the lunar regolith. Variations of the isotopic compositions of trapped He, Ne, Ar, and N in the surface layer of lunar soil grains were attributed to long term changes in the isotopic composition of solar irradiation or in the proportion of solar particles to lunar atmospheric species [1, 2, 3]. The study of such variations requires the knowledge of the antiquity of a particular sample, that is, the time when a sample was exposed to solar and lunar atmospheric particles. A practical and sensitive antiquity indicator is the ratio $^{40}Ar/^{36}Ar$ of trapped Ar, for which values of about 0.3-14 have been observed [4, 5]. Trapped ^{40}Ar mainly originates from lunar outgassing and subsequent reimplantation into lunar surface material [6, 7]. In our earlier work [8] we attempted to calibrate the evolution of $^{40}Ar/^{36}Ar$ with time based on the quantity of ^{136}Xe produced by neutron induced fission of ^{235}U in soils 74001 and 74261. In this work we present new data on breccia 14307 and some other soils and breccias that support the previous calibration.

Bernatowicz et al. [9] postulated, based on ^{136}Xe from neutron induced fission of ^{235}U, that breccia 14307 must have acquired solar gases 2-3 Ga ago. The isotopic composition of Ar has been studied for bulk samples only [10, 11], thus the $^{40}Ar/^{36}Ar$ ratio of the trapped component (tr) is not exactly known.

Results of Ne, and Ar measurements for breccia 14307,106

Grain size fractions							Trapped $^{40}Ar/^{36}Ar$
< 35 μm					5.203	6.124	5.370
	178600.000	210200.000	12.480	25.990			
35-74 μm					5.222	5.992	5.320
	216100.000	233400.000	12.620	23.220			
74-149 μm				21.40	5.202	6.105	(5.48)
	255900.000	252900.000	12.680				
149-340 μm				24.60	5.214	5.917	5.340
	280400.000	268100.000	12.590				
Average (without 74-149 μm fraction)							5.340
Ordinate intercept value for $^{40}Ar/^{36}Ar$ vs. $1/^{36}Ar$ diagram							5.270

Typical experimental errors (2σ mean) are 5% (concentrations) and 1-2% (ratios).

We prepared grain size fractions (Table) and determined the ratio $(^{40}Ar/^{36}Ar)_{tr}$ using two methods: (1) from the ordinate intercept in a diagram of $^{40}Ar/^{36}Ar$ vs. $1/^{36}Ar$ we obtain $(^{40}Ar/^{36}Ar)_{tr} = 5.27$. (2) Subtracting radiogenic ^{40}Ar (4940 ppm K [12] and crystallization age of 3.9 Ga [13]) we obtain $(^{40}Ar/^{36}Ar)_{tr} = 5.34$. The contribution of cosmogenic Ar is negligibly small. Hence, we adopt a ratio $(^{40}Ar/^{36}Ar)_{tr} = 5.30$ for 14307.

High quality calibration points: We consider the lunar surface samples 74001, 74261, and 14307 that were dated by the ^{235}U neutron fission Xe method to represent calibration points of high quality for the time dependency of the $^{40}Ar/^{36}Ar$ ratio, although experimental errors are large. In addition, the lunar soils excavated by the North Ray Crater event about 50 Ma ago [14], such as 67601, yielding $(^{40}Ar/^{36}Ar)_{tr}$ ratios of < 1 [4] are also classified as high quality points given as full circles in the Figure.

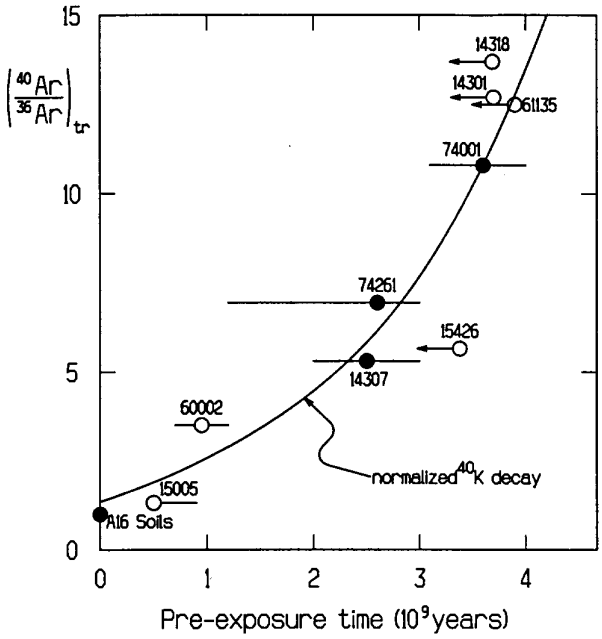

FIGURE. Ratio of trapped $^{40}Ar/^{36}Ar$ versus the time when these regolith samples were exposed on the lunar surface to solar wind and lunar atmospheric Ar. The line corresponds to the ^{40}K decay, normalized to the value of 74001. Source of data: 14301 - [15], 14318 - [5], 61135 - [16], 74001 - [8,17], 74261 - [18,8], 15426 - [19, 20], 14307 - [9, this work], 60002 - [21,22], 15005 - [23,21,24], A16 soils [21,22].

Low quality calibration points stem from (1) deposition models based on neutron capture effects observed for Apollo 15 (15005) and Apollo 16 (60002) drill core samples. (2) For another suite of samples the trapping time of Ar was derived from ^{39}Ar-^{40}Ar studies of breccias (14301, 14318, and 61135) and of green glass 15426. All references for the pre-exposure times and $(^{40}Ar/^{36}Ar)_{tr}$ data are given in the caption to the Figure.

The decrease of the $(^{40}Ar/^{36}Ar)_{tr}$ ratio with time shown in the Figure corresponds to the ^{40}K decay, normalized to the 74001 data point. We conclude that the new data confirm the previously proposed $^{40}Ar/^{36}Ar$ vs. T dependency [8] and that this isotope ratio of Ar trapped by lunar surface material is a reliable antiquity indicator.

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